PLANKTONS AS BIO-INDICATORS IN LOTIC AQUATIC ECOSYSTEM OF TUNGABHADRA RIVER NEAR HARIHAR, KARNATAKA STATE, INDIA

Abstract

Phytoplankton and zooplankton play a crucial role as bioindicators within lotic aquatic environments, contributing to the health of their respective food webs. The evaluation aimed to assess the presence and periodicity of these bioindicators in such ecosystems. The research was conducted along the Tungabhadra River near Harihar, Karnataka State, India. Plankton samples were collected using specialized nets from chosen locations within the aquatic system. Over the span of a year, a total of 465 anuran specimens were gathered, with 357 from Station 1 and 2, and 108 from Station 3 and 4. The diversity of phytoplankton and zooplankton species was recorded and quantified. Abundance referred to the number of species within a cluster in relation to the total number across all clusters. Various biological indices including Simpson’s Dominance, Gini-Simpson's, Shannon-Wiener, Berger-Parker, Margalef’s, Menhinick’s, Fisher alpha, Equitability, Brillouin, and Chao were computed using established methods. The collected species data were statistically analyzed using tools like Statistical Package for Social Sciences (SPSS) version 20.0, PAST version 3.14, and Microsoft Office. The significance level was set at $p < 0.05$. The identified bioindicators across all surveyed locations consisted of phytoplankton species such as Oscilatoria spp, Anabaenia spp, Anacystis spp, Spirogyra spp, Oedogonium spp, Savicular spp, and Euglena spp. Zooplankton species included Epiphanes spp, Philodina spp, Synchata spp, Poliathra spp, Holopedium spp, Daphnia spp, Alona

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spp, and Bosmina spp. The abundance and periodicity of these bioindicators within the selected lotic aquatic ecosystem revealed that species abundance was significantly influenced by variations in climate and weather conditions of the study area. Peak abundance was observed during the rainy period, whereas the dry period saw notably lower abundance levels.

Keywords: Abundance, Periodically, Bio-Indicators, Lotic, Aquatic, Harihar, Karnataka State.

I. INTRODUCTION

Bio-indicators play a critical role within lotic aquatic ecosystems, forming integral components of their intricate food webs. The quality of these flowing water systems can be significantly impacted by intensive agricultural practices, population growth, and industrial activities, leading to alterations in water quality due to the discharge of wastewater into the ecosystem [1]. The primary contributors to variations in lotic water quality are human-made factors, encompassing changes in the physical, chemical, and biological attributes of water, as well as the unregulated utilization of water resources [2]. The extent of these changes is contingent upon the health of the species and ecological factors. Human activities, along with the influence of climate change, are likely to exert considerable influence on species populations. Particularly in lotic aquatic systems, phytoplankton stands as a pivotal species at the primary trophic level, assuming the role of the foundational link in the aquatic food chain. According to [5], optimal phytoplankton production occurs under conditions where physico-chemical variables adhere to standard values. Among the significant indicators of water quality is the abundance of phytoplankton populations [6]. In the realm of aquatic environments, the three major families of algae are Chlorophyta, Cyanophyta, and Bacillariophyta. Shifts in nutrient levels and water quality often coincide with changes in algal diversity [7, 8]. It is worth noting that some previous studies have identified mobile phytoplankton species as indicators for lentic aquatic systems as well [9 - 11]. This present study aims to assess the prevalence and periodicity of bio-indicators within a lotic aquatic ecosystem adjacent to Harihar in the Karnataka State of India.

II. MATERIALS AND METHOD

Samples of water and algae are gathered at regular 15-16 day intervals across four designated locations spanning 365 days. In the latest assessment, these locations were chosen based on the criteria of algal prevalence and human activities.

III. STUDY AREA

The work was performed in Tungabhadra River near Harihar of Karnataka State. Tungabhadra River in Karnataka is a significance tributary of Krishna. It has a drainage zone of 71,420 sq.km out of 57,542 sq.km lies in the Karnataka state. It covers a distance of 292 km in the Karnataka state and is getting contaminated due to rapid industrial activities, domestic and agricultural practices in the zone. Contamination is as old as human beings himself, in prehistoric era the population was very less, the man adopted to move from location to location in search of food and better life. The district Davangere is situated in the central part of Karnataka state (India) located from latitude 14O 17’ and 14O 35’ N and longitude 75O 50’ and 76O 05’ E covering an zone of 6530 sq. km at an average altitude of 540 m above MSL.

The river Tungabhadra acts as a natural boundary, delineating the neighboring Haveri district. Four strategic sites have been pinpointed for conducting a comprehensive limnological investigation into the various algae present in distinct aquatic habitats within the flowing ecosystem of the river, which holds significant prominence within India. The research undertaken regarding the limnological facets assumes paramount importance in the sustainable exploitation of aquatic resources. Fluctuations occurring at regular intervals in biotic factors have a discernible impact on the distribution patterns and population densities of plant and animal species (Hassa 1998). The presence and distribution of phytoplankton and zooplankton in freshwater bodies are primarily governed by abiotic factors (Muhauser et al 1995). This ongoing study specifically aims to catalog the phytoplankton species thriving within the Tungabhadra River.

IV. STUDY DESIGN AND SAMPLING

1. **Station (S1):** The location of this habitat is situated at the upstream town before the river enters into town.

2. **Station (S2):** This location is situated on the main watercourse of river Tungabhadra in a place its near the confluence place of sulekere stream (Tributary)

3. **Station (S3):** This location is situated at the downstream of Harihar Polyfibers treated waste water discharge (near Harlapura).

4. **Station (S4):** This sampling location is situated about 2 km for away from Location -S2.

Four sampling locations were chosen along a 30 km stretch of the Tungabhadra River to ensure comprehensive coverage. Water samples were collected for physico-chemical analysis following the established methods outlined in APHA (1995) and Trivedy and Goel (1986) guidelines. Algae specimens were preserved in a 4% formaldehyde solution to facilitate identification. Identification of Chlorophyceae and Euglenophyceae utilized the key provided by Smith (1950) and Prescott (1978), while Cyanophyceae were identified using Desikachary's (1959) method, and Bacilleriophyceae were identified following Hendey's (1964) approach (see Table 6). The data analysis encompassed statistical computations, correlations, and inter-correlation matrices, which were separately applied to both physico-chemical variables and phytoplankton data (see Table 6).

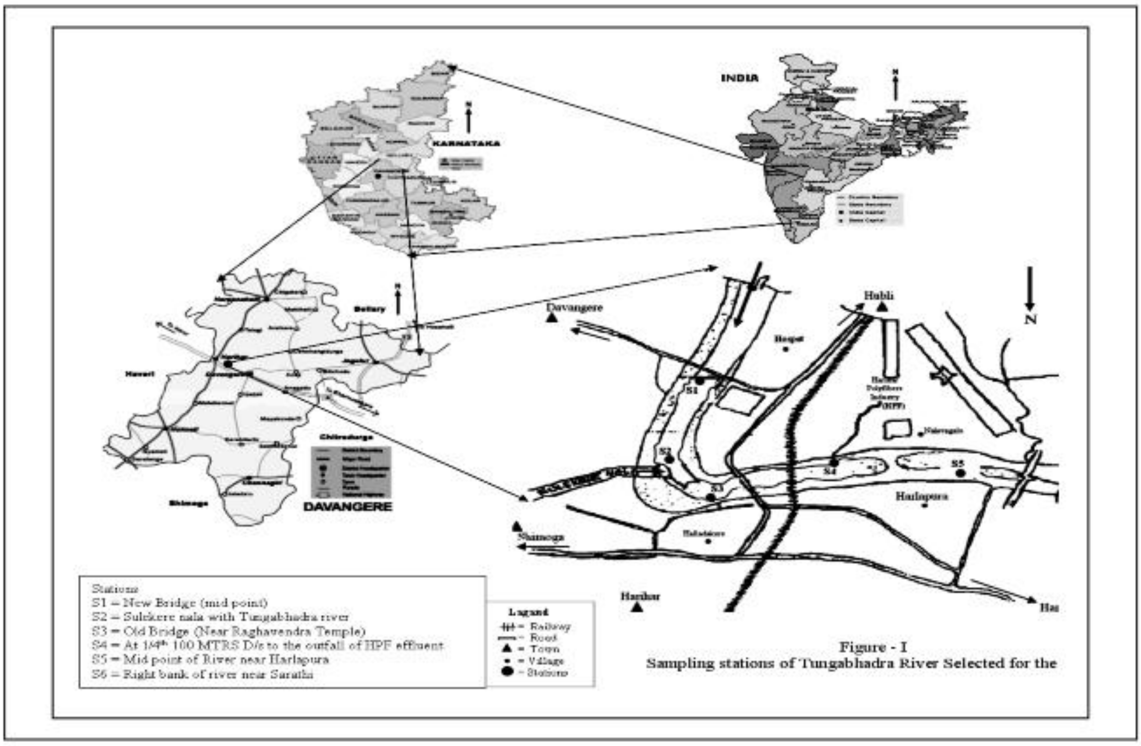

Figure - I
Sampling stations of Tungabhadra River Selected for the

The enumeration of phytoplankton and zooplankton species' abundance took place. This involved quantifying the number of species within a cluster relative to the total number of species across all clusters under examination. The calculation of indices followed the methodology outlined in references [15] and [16]. To assess each species, metrics such as Brillion's diversity index and Simpson's index of dominance were employed. The equations utilized for these calculations were as follows:

Simpson's index, D = i=$\sum_{i=1}^{S} p2$

Where p is the proportional counts of ith species

Gini-Simpson index = 1- D

Shannon-Wienner's index, H' = $-\sum_{i=1}^{S} p\mathrm{Ln}(p)$

Where p is the proportional counts of ith species

Berger – parker index of Dominance, d = NmaxN

N_{max}= number of species in the most abundant species. N = total number of species in sample

V. PLANKTON COLLECTION

Planktons were collected using plankton net in all the sample location and carried in sterile bottles to the laboratory for identification.

VI. 2.5 DATA APPRAISAL

The data was appraised adopting the Statistical Packages for Social Sciences (SPSS) version 20.0, PAST (Paleontological Statistics) version 3.14 and MS Office Excel.

VII. RESULT AND DISCUSSION

1. **Relative Abundance of Phytoplankton and Zooplankton:** The tabulation in Table 1 outlines the collective count of species gathered from the sampling sites. At Station 1 and Station 4, an equivalent number of species were collected, each yielding three distinct species, along with 7 phytoplankton and 8 zooplankton species. Symmetry was maintained in species collection across both locations. Irrespective of the sampling approach, the most noteworthy presence was that of Amietophrymus regularis, constituting 28.32% and 37.23% at Station 1 and Station 2, and 19.32% and 14.21% at Station 3 and Station 4 respectively, followed by Amietophrymus maculatus at 18.82% and 19.82%, and Hoplobatracchus occipitalis at 19.32% and 14.21%. The relative abundances of phytoplankton species ranged between 1.5% and 3.5%, while for zooplankton species, the range was 1.0% to 3.0%. Across all sampling methods, anuran relative abundances exceeded 62% in each location, while both phytoplankton and zooplankton accounted for less than 20%, as depicted in Figure 1.

   Within the trio of annual species, A. regularis exhibited the highest prevalence, comprising 44% and 51% of the total annual species in Station 3 and Station 4 respectively, as illustrated in Figure 2. A. maculatus demonstrated uniform relative abundance of 28% across both stations in comparison to other anuran species. Relative to the two previously mentioned annual species, H. occipitalis constituted 29% and 20% of abundance in Station 3 and Station 4 respectively.

Table 1: Relative Abundance of Phytoplankton and Zooplankton Species

		Location 1 and 2		**Location 3 and 4**	
Groups	Species	**Total**	Relative Abundance (%)	**Total**	Relative Abundance (%)
Phytoplankton	*Oscillatoria* spp.	30	8.40	13	12.04
	Anabaenia spp.	33	9.24	7	6.48
	Analystis spp.	24	6.72	3	2.78
	Spirogyara spp.	37	10.36	15	13.89
	Oedogonium spp.	18	5.04	5	4.63
	Savicular spp.	34	9.52	7	6.48
	Euglena spp.	24	6.72	8	7.41
Zooplankon	*Epiphanes* spp.	22	6.16	7	6.48
	Philodina spp.	26	7.28	11	10.19
	Synchata spp.	32	8.96	4	3.70
	Poliathra spp.	18	5.04	4	3.70
	Holopedium spp.	14	3.92	2	1.85
	Daphnia spp.	16	4.48	11	10.19
	Alona spp.	18	5.04	6	5.56

	Bosmina spp.	11	3.08	5	4.63
	Total	357	100	108	100

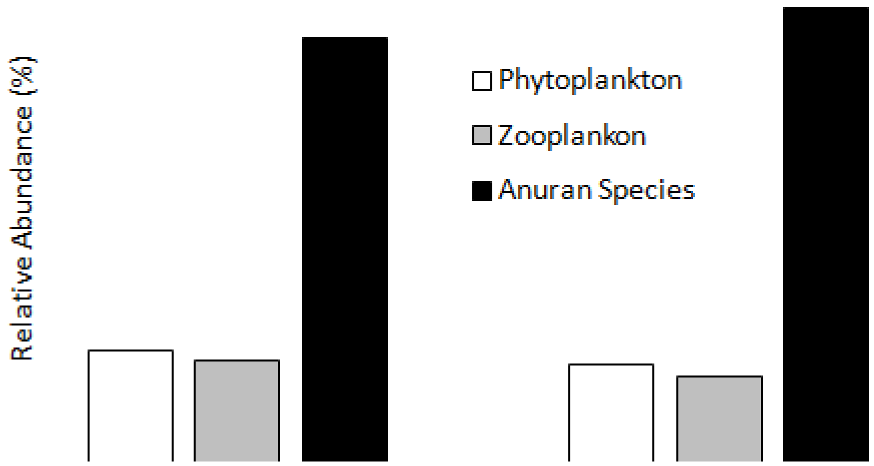

Figure 1: Relative Abundance of Phytoplankton and Zooplankton Species

In Station 1 and Station 2, the most prevalent phytoplankton species was Spirogyra spp., constituting the majority at 10%, while Euglena spp. and Analyst spp. were the least abundant at 6%. The second-highest in richness was Savicular spp. at 9%. Analystis spp. and Euglena spp. accounted for 24% each (depicted in Figure 3A). Regarding the zooplankton, Synchata spp. took the lead with 8% abundance, closely pursued by Philodina spp. at 7%, and Epiphanes spp. at 6%. The scarcest zooplankton observed was Bosmina spp., comprising only 3% (shown in Figure 3B).

Moving to Station 3 and Station 4, Spirogyra spp. dominated the phytoplankton composition with the highest abundance of 14%, trailed by Oscillatoria spp. at 12%. The least prevalent phytoplankton was Analystis spp., constituting a mere 2%. Anabaenia spp. and Savicular spp. had an equal presence of 6% (illustrated in Figure 4A). Among the zooplankton species in these stations, Philodina spp. and Dapnia spp. were the most abundant, each at 11%, followed by Bosmina spp. (5%) and Alona spp. (6%) at a slight distance. The scarcest zooplankton at these stations was Holopedium spp., accounting for only 2% (depicted in Figure 4B).

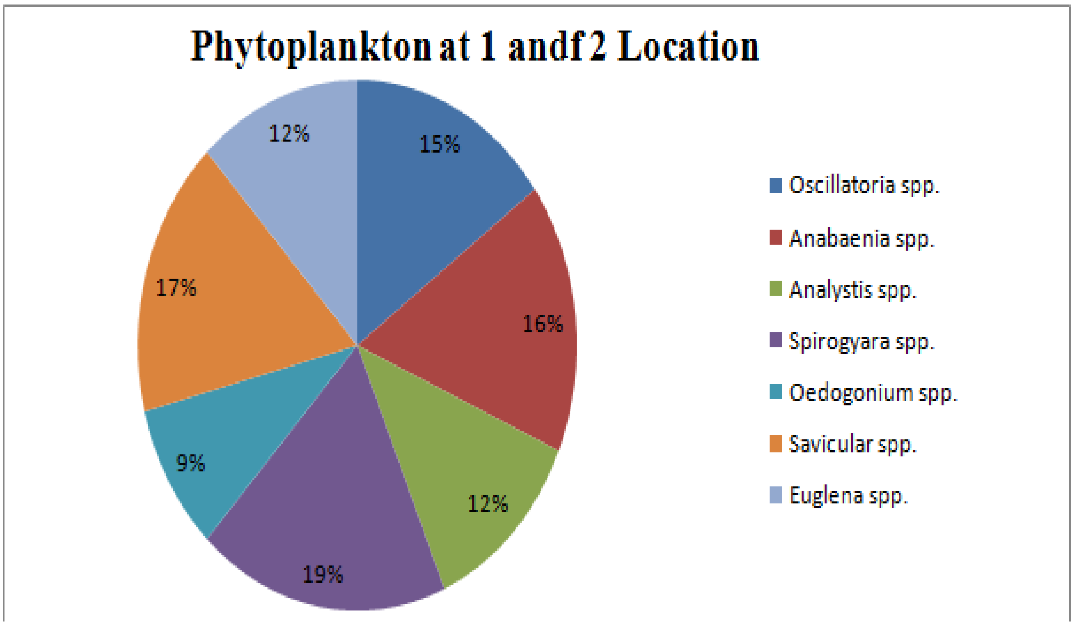

Figure 3A: Relative Occurrence of Species of Phytoplanktons in Location 1 and 2

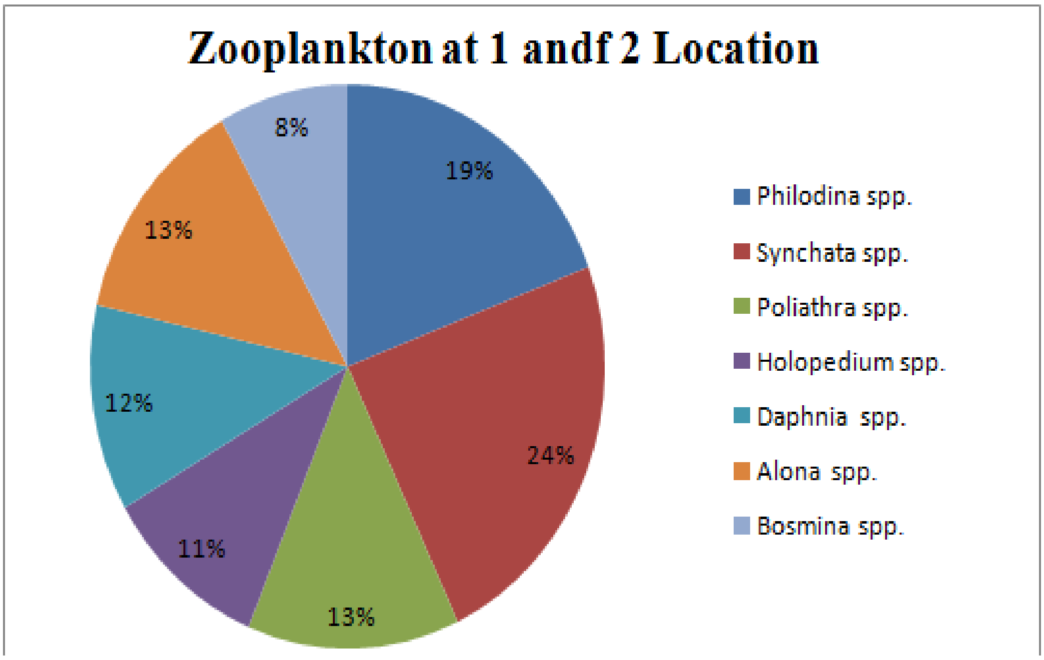

Figure 3B: Relative Occurrence of Species of Zooplankton in Location 1 and 2

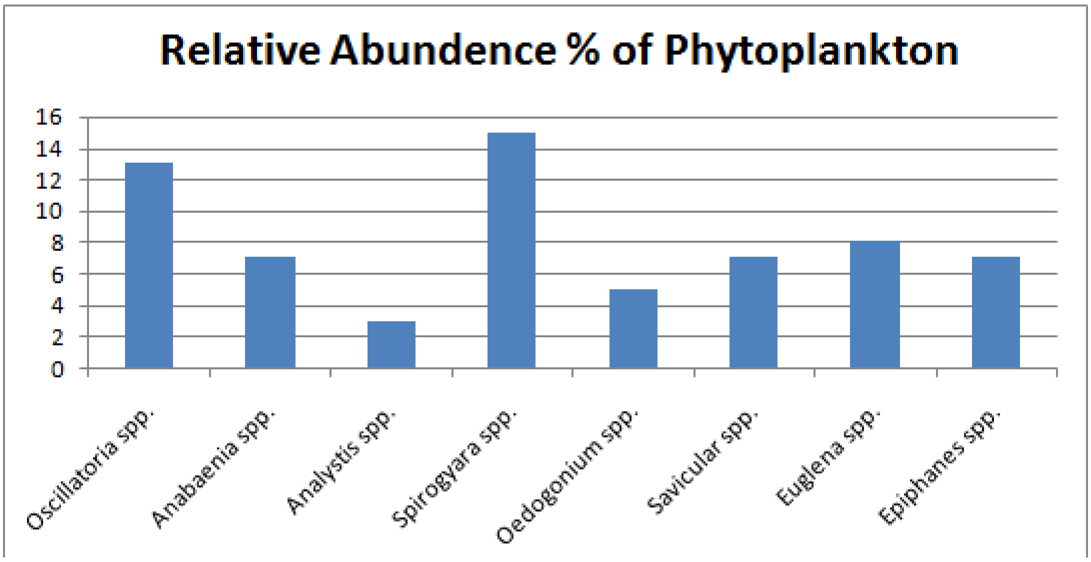

Figure 4A: Relative Occurrence of Species of Phytoplanktons in Location 3 and 4

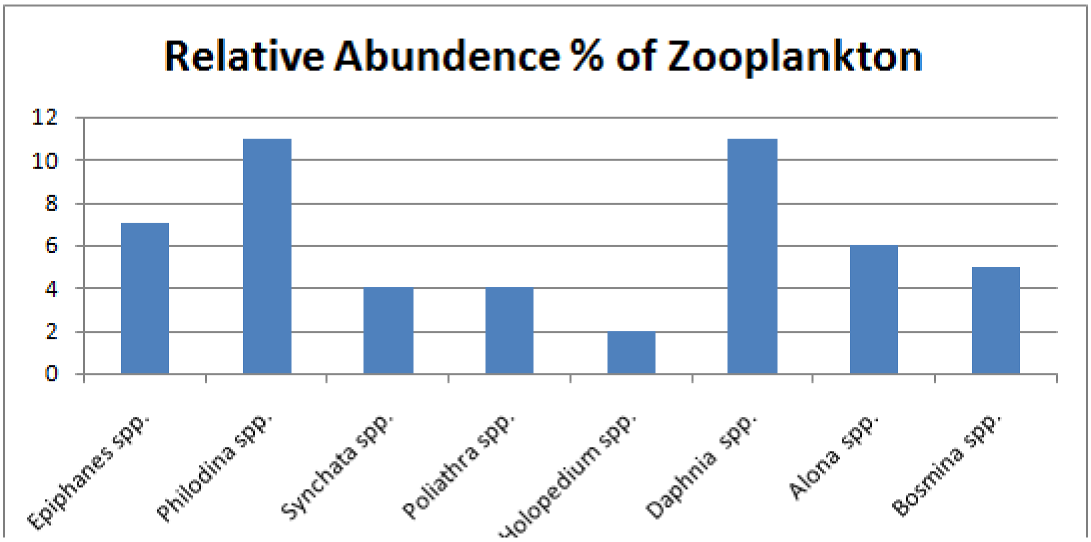

Figure 4B: Relative Occurrence of Species of Zooplankton in Location 3 and 4

2. **Overall Monthly Abundance of Species in Selected Locations:** The period from July to November exhibited a substantial abundance of both phytoplankton and zooplankton in the sampled areas. During the dry months of December, January, February, and March, there was generally lower species richness. However, it's important to note that no samples were collected in January and February at locations 3 and 4 (refer to Figure 5A, B).

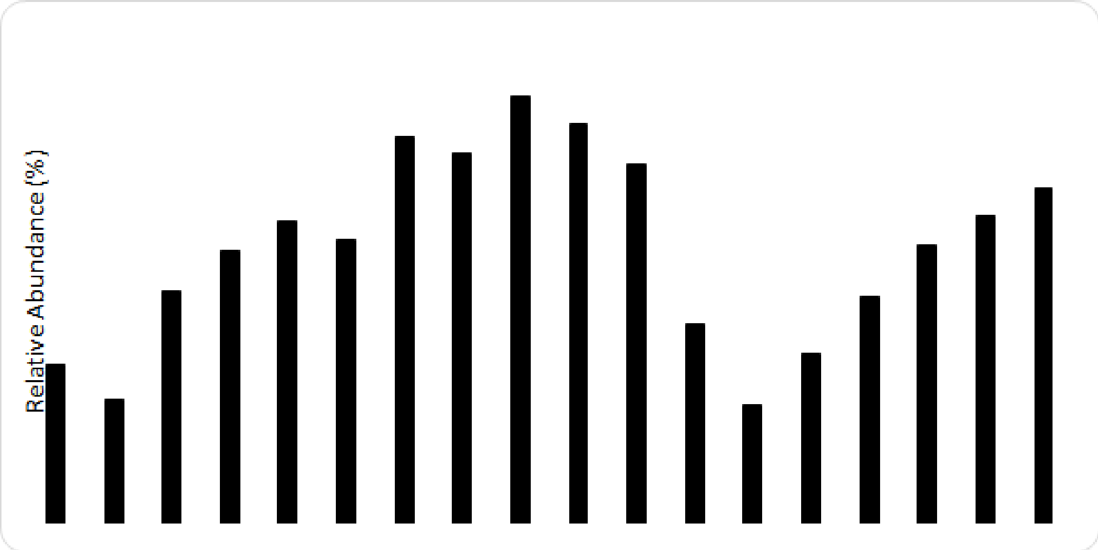

Figure 5A: Monthly Relative Abundance of Phytoplankton and Zooplankton in Selected Locations from January 2021 to June 2022 in Station 1 and Station 2

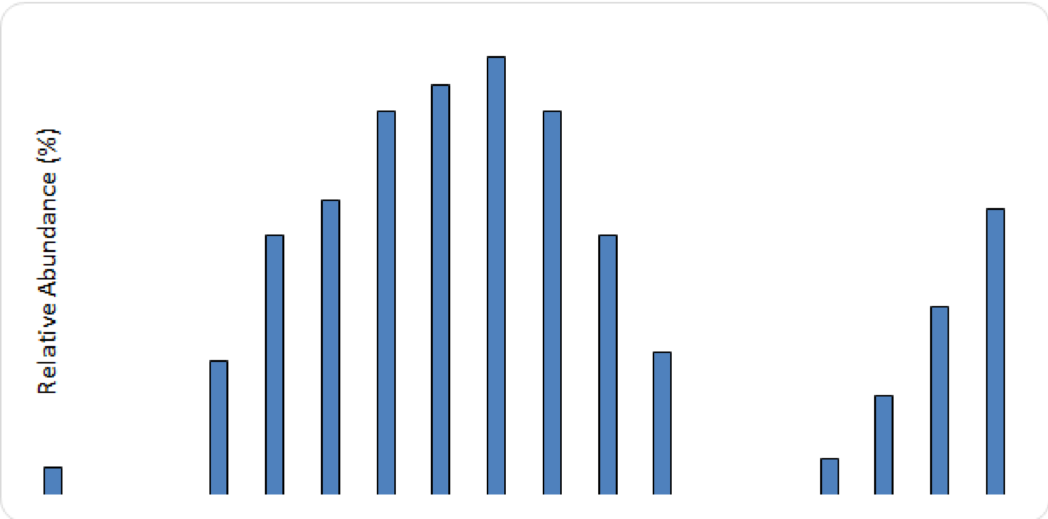

Figure 5B: Monthly Relative Abundance of Phytoplankton and Zooplankton in Selected Locations from January 2021 to June 2022 in Station 3 and Station **4**

VIII. DISCUSSION

From the obtained analytical data, the richest species among the studied organisms were phytoplankton, comprising 24% and 38% of the composition at Station 1 and Station 2 respectively. For Amietophrynus regularis, the values were 18.9% and 19.6%, and for Amietophrynus maculata, they were 19.3% and 14.2% at Station 3 and Station 4 respectively. Similarly, Hoplobatracchus ocipitalis accounted for 19.3% and 14.2% at the same respective stations. These findings align with previous reports by [17] indicating that the order species constitute the majority (86%) of amphibian species. The analytical results also revealed that the relative species richness at each sampling location exceeded 62%.

Among the six zooplankton species, one species stood out as the most abundant, representing 43% and 52% of the total anuran species count at Station 1 and Station 2, and Station 3 and Station 4 respectively. The discrepancies in abundance could be attributed to variations in water quality [18]. Notably, A. maculatus demonstrated equal abundance of 28% across both study stations, while H. occipitalis exhibited 29% and 20% abundance at Station 1 and Station 2, and Station 3 and Station 4 respectively.

The anuran species found across all four stations were Amietophrymus regularis, Amietophrymus maculate, and Hoplobatocchus occipitalis. This contrasts with the findings of [19], which focused solely on Amietophrymus regularis. The divergence in results was due to their study being conducted in a different community compared to our research station. These three species share the commonality of being toads, differentiated by size, coloration, and unique disc-shaped structures on their toe tips, an adaptation aiding vertical movement [20]. The discrepancies in phytoplankton abundance between Abuja, Station 3, and Station 4 likely stem from variations in water quality, river water duration, and surrounding vegetation [18].

Considering seasonal conditions, observations revealed that frogs thrived under higher rainfall and more humid environments. Wet months saw a surge in frog populations, with September exhibiting a peak coinciding with metamorphic cycles. This trend corroborates [17]'s report. Conversely, dry seasons hindered these conditions, leading to a significant decrease in frog numbers. Similar patterns were observed in the forest swamp of the river Niger delta in southeastern Nigeria [21]. During dry spells, frogs migrated from drying temporary pools to larger, permanent water bodies. Some hibernated under forest floor leaves or in riverbed substrates. Monthly trends in phytoplankton and zooplankton abundance mirrored those of anuran species, with peak levels in the rainy season, particularly in September. Station 3 and Station 4 displayed no species during the dry months of January and February 2016, and February and March 2017, due to inadequate pond water. This aligns with [22]'s observations of species abundance and its correlation with seasonal bimodal rainfall patterns and environmental factors.

These species thrive extensively in tropical regions, including savannas, mountains, grasslands, and forests. They contribute to nutrient cycles and serve as environmental indicators. Toads, after metamorphosis, transfer nutrients from aquatic to terrestrial ecosystems. Tadpoles, the aquatic larvae of toads and frogs hatched from fertilized eggs, serve as crucial food sources for aquatic organisms, including fish.

IX. CONCLUSION

The population levels and seasonal patterns of anurans, phytoplankton, and zooplankton were investigated in various chosen river sites within Karnataka state. The Tungabhadra river, in particular, revealed a distinct trend where the abundance of these organisms is greatly impacted by the changing seasons in Karnataka. The zenith of their abundance is observed during the rainy season, whereas their numbers sharply decline during the dry season.

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